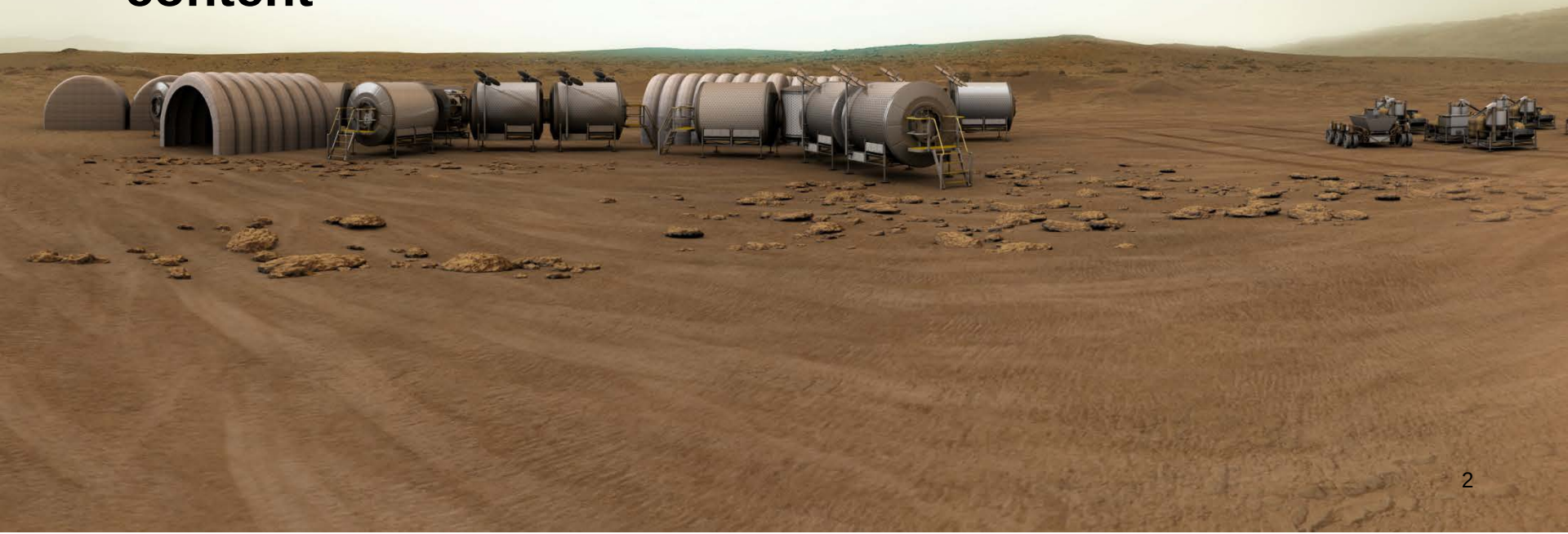
National Aeronautics and Space Administration

Deep Space Gateway - Enabling Missions to Mars

Mars Study Capability Team – Michelle Rucker, John Connolly

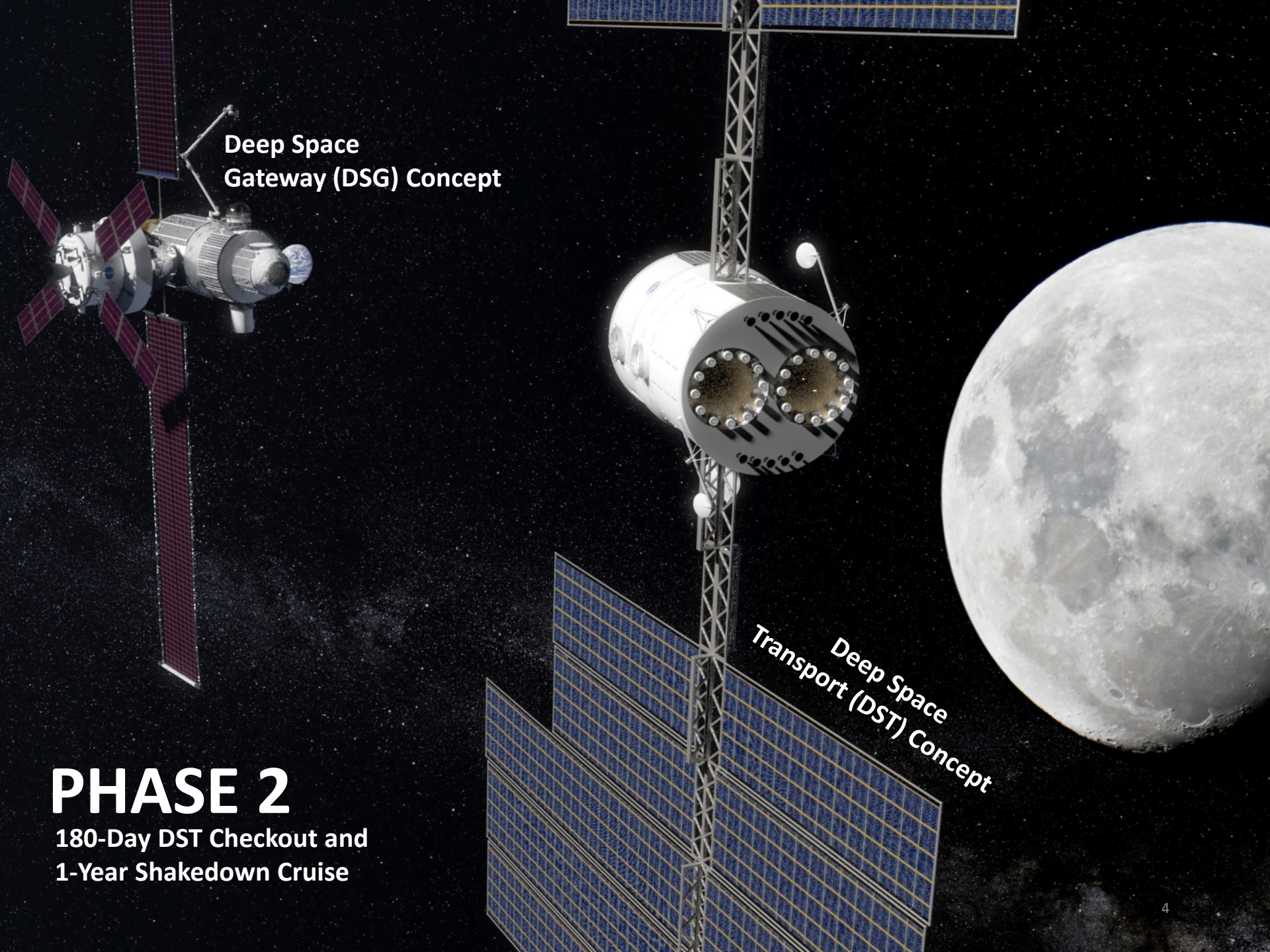
Introduction

- **The Global Exploration Roadmap reflects that human missions to Mars remain the consensus horizon goal of participating agencies**
  - Sustainable human missions, including missions to the lunar surface, will be enabled by international cooperation
- **NASA analyses and planning for Mars missions have informed Global Exploration Roadmap timing and content**



Deep Space Gateway & Transport Extensibility to Mars

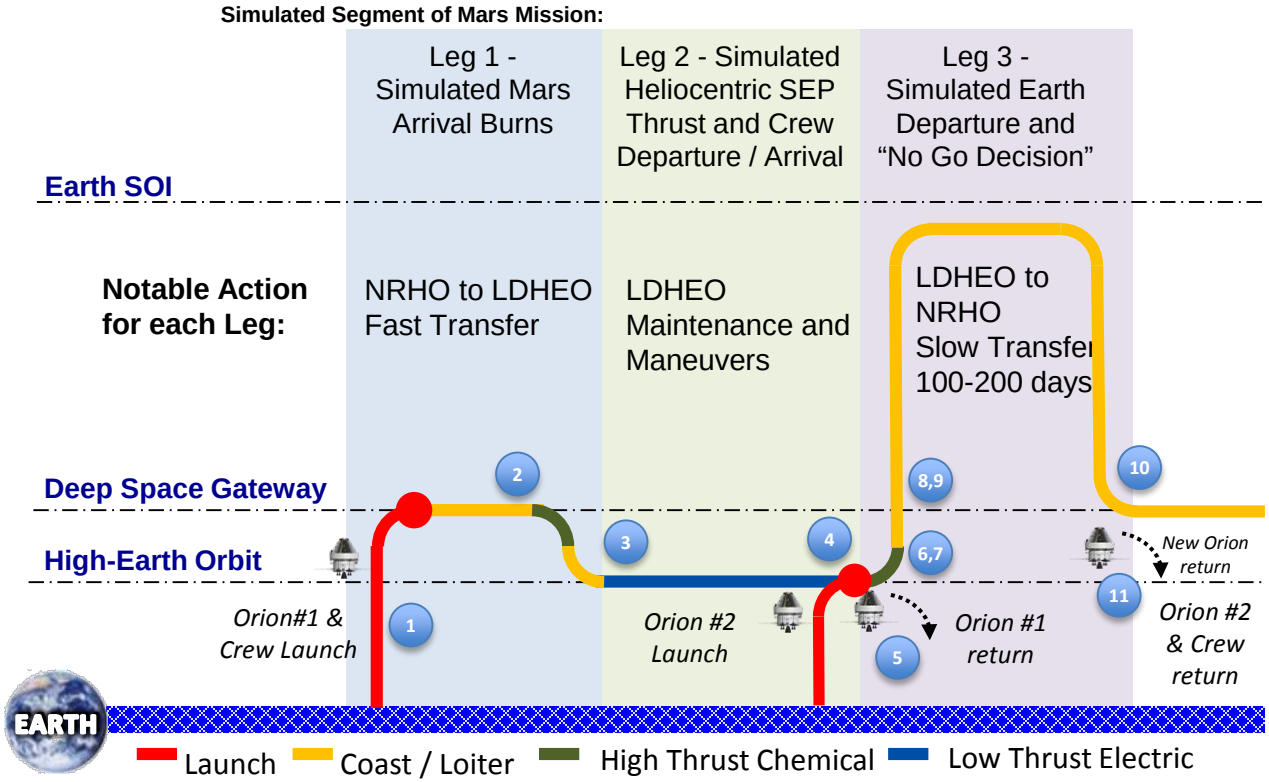
- **There are many opportunities for commonality between Lunar vicinity and Mars mission hardware and operations**
  - Best approach:
    - Identify Mars mission risks that can be bought down with testing in the Lunar vicinity
    - Then explore hardware and operational concepts that work for both missions with minimal compromise
- **Deep Space Transport will validate the systems and capabilities required to send humans to Mars orbit and return to Earth**
  - Deep Space Gateway provides a convenient assembly, checkout, and refurbishment location to enable Mars missions
- **Current deep space transport concept is to fly missions of increasing complexity**
  - Shakedown cruise, Mars orbital mission, Mars surface mission
    - *Mars surface mission would require additional elements*



PHASE 2

180-Day DST Checkout and
1-Year Shakedown Cruise

Shakedown Cruise
Simulating Key Segments of Mars Orbital Mission



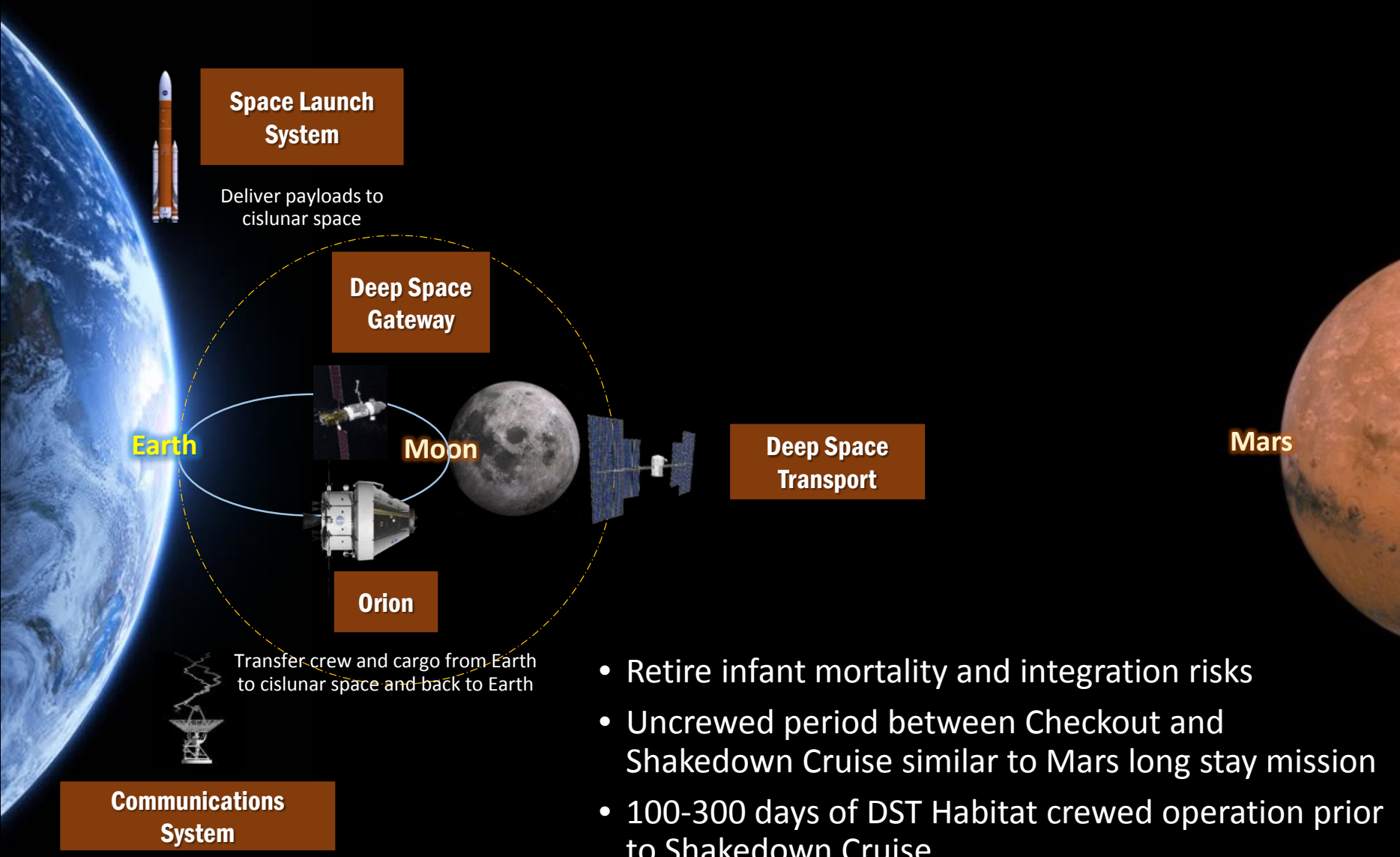
#	Crew Phase Critical Event
1	Orion launches and delivers crew to DSG and DST integrate stack in **Near Rectilinear Halo Orbit (NRHO)**
2	DST with Orion departs DSG and performs fast transfer into **Lunar Distant High Earth Orbit (LDHEO)**
3	DST uses SEP in LDHEO to demonstrate long duration maneuvers without leaving Earth sphere of influence
4	New Orion launches to LDHEO and rendezvous with DST and original Orion (Option to swap crew before Shakedown)
5	Orion #1 departs DST and returns to Earth
6	DST performs maneuver to target Lunar Gravity Assist (LGA) 1
7	DST catches LGA 1 that targets LGA 2
8	DST performs final Earth departure checks but does not perform final maneuver to target Earth departure LGA
9	DST catches LGA 2 back to NRHO via slow transfer
10	DST inserts into cislunar and rendezvous with Gateway
11	Orion departs DST and returns crew to Earth

Mars Mission Comparison

	Shakedown Cruise	Mars Orbital Mission
Chemical Engine Starts	~ 7	~ 7
Max Single Burn Duration	~ 0.8 hr	~ 0.8 hr
Total Chem Burn Duration	~ 1.9 hr	~ 2.4 hr
SEP Burn Duration	~ 90 d	~ 329 d

Shakedown Cruise validates Deep Space Transport for cargo and human missions to Mars

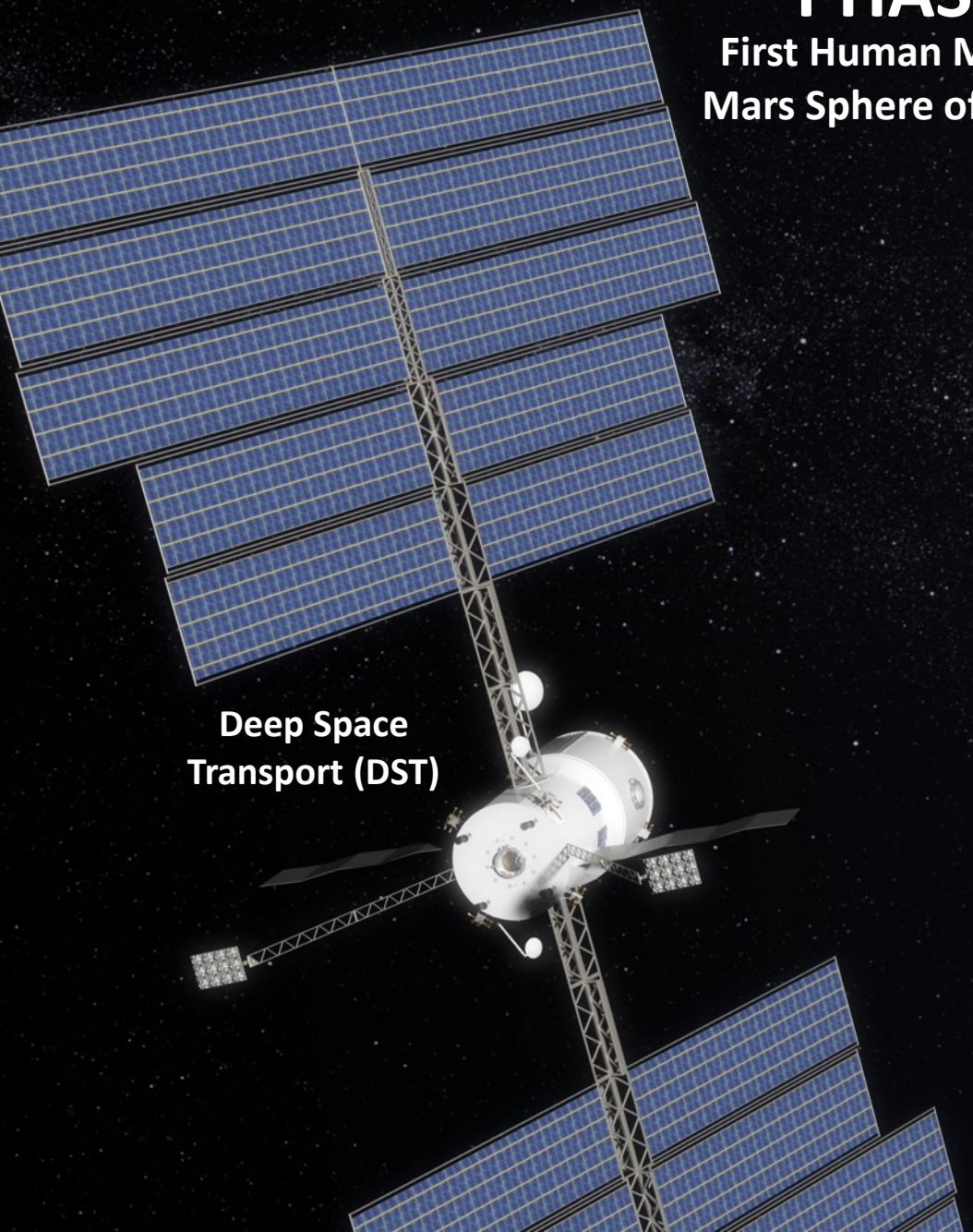
Example Phase 2 Mission Elements
DST Checkout and Shakedown Cruise



- Retire infant mortality and integration risks
- Uncrewed period between Checkout and Shakedown Cruise similar to Mars long stay mission
- 100-300 days of DST Habitat crewed operation prior to Shakedown Cruise

PHASE 3

First Human Mission to Mars Sphere of Influence



Deep Space Transport (DST)

First human mission to Mars' sphere of influ

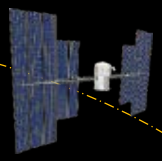
- First long duration flight with self sustained syst
- Autonomous mission, extended communicatio
- First crewed mission with limited abort opportu

Example Phase 3 Mission Elements
Mars Orbital Mission

Space Launch System

Deliver payloads to cislunar space

Deep Space Transport

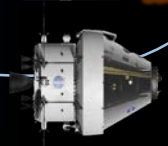


Deep Space Gateway

Earth

Moon

Mars



Orion

Transfer crew and cargo from Earth to cislunar space and back to Earth

Communications System

Earth-to-Mars communication

Crew Operations in Martian Vicinity

PHASE 4

Mars Surface Missions

Emphasis on establishing Mars surface field station

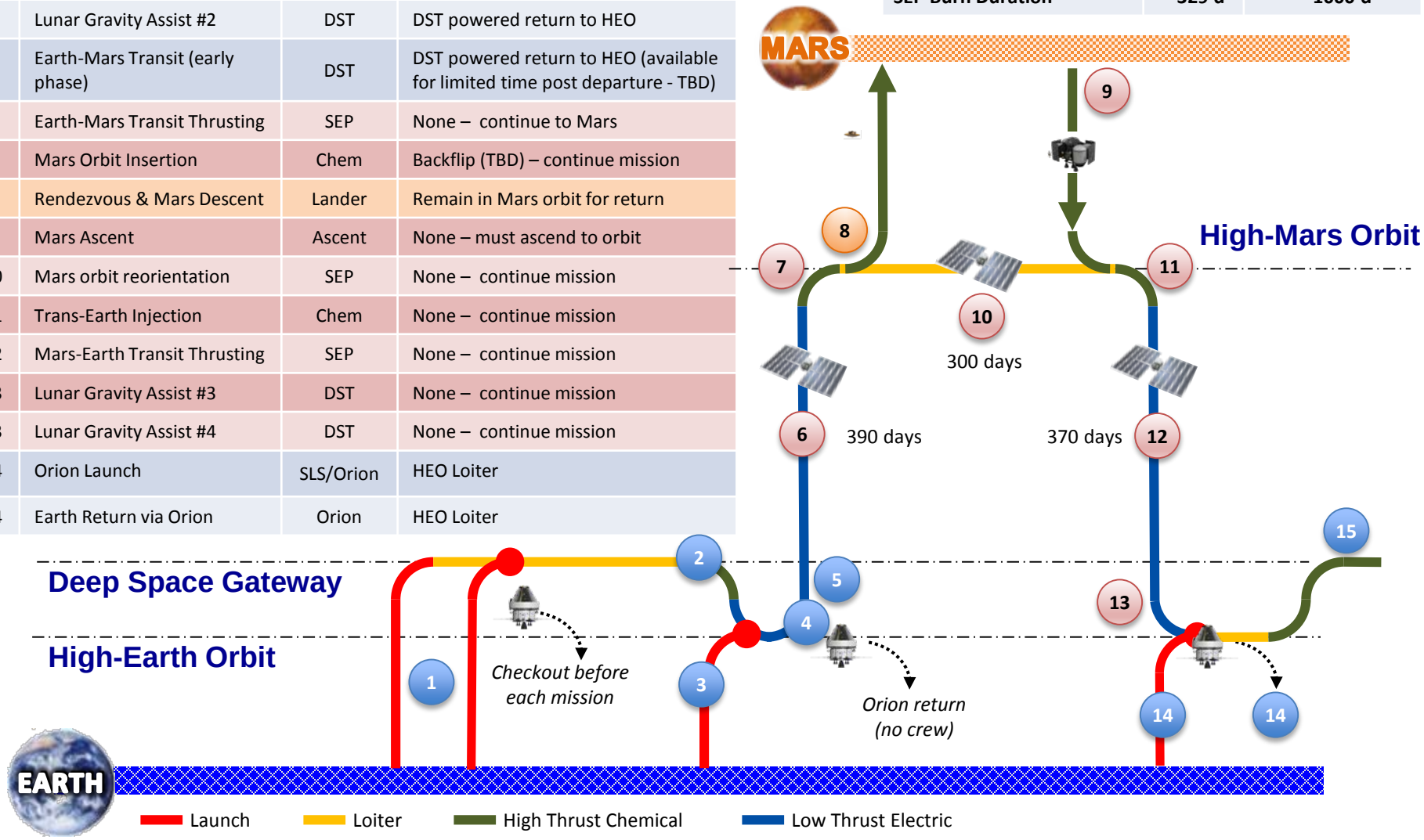
- First human landing on Mars' surface
- First three missions revisit a common landing site

Crewed Mars Orbital & Surface Leg

Example Operational Concept

Mars Mission Comparison	Orbital	3 Mars Missions
Chemical Engine Starts	~ 7	~ 20
Max Single Burn Duration	~ 0.8 hr	~ 0.8 hr
Total Chem Burn Duration	~ 2.4 hr	~ 8.0 hr
SEP Burn Duration	~ 329 d	~ 1000 d

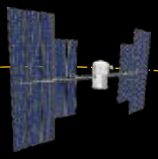
#	Crew Phase Critical Event	Sys.	Return to Earth Options
4	Lunar Gravity Assist #1	DST/Orion	DST powered return to HEO / Orion return
5	Lunar Gravity Assist #2	DST	DST powered return to HEO
5	Earth-Mars Transit (early phase)	DST	DST powered return to HEO (available for limited time post departure - TBD)
6	Earth-Mars Transit Thrusting	SEP	None – continue to Mars
7	Mars Orbit Insertion	Chem	Backflip (TBD) – continue mission
8	Rendezvous & Mars Descent	Lander	Remain in Mars orbit for return
9	Mars Ascent	Ascent	None – must ascend to orbit
10	Mars orbit reorientation	SEP	None – continue mission
11	Trans-Earth Injection	Chem	None – continue mission
12	Mars-Earth Transit Thrusting	SEP	None – continue mission
13	Lunar Gravity Assist #3	DST	None – continue mission
13	Lunar Gravity Assist #4	DST	None – continue mission
14	Orion Launch	SLS/Orion	HEO Loiter
14	Earth Return via Orion	Orion	HEO Loiter



Example Phase 4 Mission Elements

Space Launch System

Deliver payloads to cislunar space



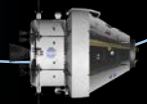
Deep Space Transport, Hybrid SEP Cargo Transport

Transport 100-200t aggregated payloads and crew between Earth and Mars

Entry-Descent Lander

Land 20-30 t payloads on Mars

Deep Space Gateway



Earth

Moon

Mars

Mars Ascent Vehicle

Transfer crew and cargo from the Mars surface to Mars orbit

Orion

Transfer crew and cargo from Earth to cislunar space and back to Earth

Communications System

Earth-to-Mars, Mars surface-to-Mars orbit, and Mars surface-to-surface communication

Crew Operations in Martian Vicinity

Surface Habitat and Science Lab

Sustain 4 crew for up to 500 days per Expedition

Logistics Carrier

Deliver equipment and consumables

Surface Mobility

Planetary Space Suits and robotic or pressurized rovers

Surface Utilities

Power, In Situ Resource Utilization

Key Take Aways

- **Cislunar and Lunar surface missions can feed forward to human Mars missions**
  - Mars testbed
- **Deep Space Gateway provides a convenient assembly, checkout, and refurbishment location to enable Mars missions**
- **Deep Space Transport shakedown cruise will validate the systems and capabilities required to send humans to Mars orbit and return to Earth**
  - DST provides Mars orbital mission capabilities
    - Additional developments will be required for Mars surface mission

Questions?

Mars Study Capability Team
XM/M. Rucker, michelle.a.rucker@nasa.gov
XM/J. Connolly, john.connolly-1@nasa.gov